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2CAN080306

August 27, 2003

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

SUBJECT: Arkansas Nuclear One, Unit 2
Docket No. 50-368
License No. NPF-6
Supplemental Response to the Bare Metal Visual Relaxation Request for ANO-2 Regarding NRC Order EA-03-009

REFERENCES:

1 NRC letter dated February 11, 2003, *Issuance of Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads at Pressurized Water Reactors* (0CNA020302)

2 Entergy letter dated May 8, 2003, *Request for Relaxation from Section IV.C(1)(a) of the Order Establishing Interim Inspection Requirements for Reactor Pressure Vessel Heads* (2CAN050301)

3 Entergy letter dated June 26, 2003, *Response to Request for Additional Information on the ANO-2 Relaxation from Performing a Bare Metal Visual Inspection from the February 11, 2003 Reactor Pressure Vessel Head Order* (2CAN060308)

4 Entergy letter dated August 2, 2003, *Response to Request for Additional Information on Relaxation from Performing a Bare Metal Visual Inspection on the ANO-2 Reactor Vessel Head* (2CAN080302)

Dear Sir or Madam:

On February 11, 2003, the Nuclear Regulatory Commission (NRC) issued an Order addressing interim inspection requirements for reactor pressure vessel (RPV) heads at pressurized water reactors (Reference 1). The NRC stated that the actions in the Order are interim measures, necessary to ensure that licensees implement and maintain appropriate measures to inspect and, as necessary, repair RPV heads and associated penetration nozzles. On May 8, 2003, Entergy Operations, Inc. (Entergy) requested relaxation from Section IV.C(1)(a) of the Order (Reference 2) to perform a bare metal visual (BMV) inspection of 100 percent of the RPV head surface for Arkansas Nuclear One, Unit 2 (ANO-2). In response to initial requests for additional information (RAI), Entergy submitted examination and inspection approaches for the upcoming ANO-2 refueling outage to provide diverse and complementary actions for relaxation of the Order (Reference 3).

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During a conference call with the NRC staff on July 14, 2003, the NRC requested additional information which included a request for details of the newly proposed examination techniques for the low frequency eddy current testing of the penetration annulus and the triple point examination of the penetration J-groove weld. Entergy's response to this RAI was provided on August 2, 2003 (Reference 4). A follow-up meeting was conducted in the NRC offices on August 14, 2003, at which time a further clarification was requested of Entergy on the application of the alternative examination techniques being applied on ANO-2. The additional RAI and Entergy response is contained in Attachment 1 of this letter.

An additional commitment is being made in Attachment 1 and is listed in Attachment 2. If you require additional information, please contact Steve Bennett at 479-858-4626.

Sincerely,

Sherrie R. Cotton

Sherrie R. Cotton
Director, Nuclear Safety Assurance

SRC/sab

Attachments
1. Supplemental Response to the Bare Metal Visual Relaxation Request for ANO-2 Regarding NRC Order EA-03-009
2. List of Regulatory Commitments

cc: Mr. Thomas P. Gwynn
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Attachment 1

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Supplemental Response to the Bare Metal Visual Relaxation Request for ANO-2 Regarding NRC Order EA-03-009

Supplemental Response to the Bare Metal Visual Relaxation Request for ANO-2 Regarding NRC Order EA-03-009

NRC RAI 1:

Regarding the "Triple-Point" detection capability of the volumetric ultrasonic technique that will be used at ANO-2:

a) *What demonstration mock-up flaws (including Entergy and/or MRP) were detected correctly in the weld triple-point area, which make the case for this inspection approach?*

ANO Response:

Flaws 1, 5, and 6 in the Entergy/MRP mock-up, and Flaw 2 in the Materials Reliability Program (MRP) Phase II Demonstration mock-up "K" were the flaws that were successfully detected by Westinghouse which make the case for the triple-point inspection approach. The weld flaws in the EPRI mockups are designated as types M, N and O flaws. In the Entergy/ MRP Mockup there were a total of 12 tube and weld flaws as shown in the enlarged figure contained in Attachment 3 of Reference 4. Flaws 1, 4, 5, 6, 8 and 12 were weld flaws as follows:

- type M flaws are radial-axial (flaws 4, 8, and 12),
- type N flaws are circumferential-axial (flaw 6), and
- type O flaws are circumferential-axial placed near the weld-to-clad interface (flaws 1 and 5).

The type N and O flaws detected were flaws 1, 5 and 6. Each of these flaws was successfully detected due to the fact that, in each case, the tip of the flaw came within the declared detection capability of the triple point examination.

In the Phase II "K" Mockup, there were 9 J-groove weld flaws as shown on Figure 2 of WesDyne Report WDI-TJ-012-03 (Reference 4) as follows:

- type M flaws are flaws 2, 4, 7, and 9,
- type N flaws are flaws 1, 6, and 8, and
- type O flaws are flaws 3 and 5.

It should be noted that flaws 2, 7, and 9 are the only flaws that are within the depth of the declared detection capability of the triple point ultrasonic testing (UT) examination. The flaw that was detected was flaw 2, which was 100% to the triple point of the J-groove weld.

The flaws detected from the two mockups are considered to be the most appropriate type of flaws for confirming the capability of the triple point method.

b) *What demonstration mock-up flaws were missed in the welds, and why is that acceptable to the ANO-2 case?*

ANO Response:

In the Entergy/MRP mock-up, the radial-axial (type M) flaws were masked by nozzle tube flaws and were not called as flaws. These missed detections are considered acceptable because they were not considered detectable by the UT scans as further discussed below. In addition, the masking flaws in the nozzle wall were successfully detected (type PTI per the analysis guidelines). This result would require an additional surface examination of the J-groove weld, which would be capable of detecting the flaws in the weld.

The type M flaws that were missed in the "K" Phase II mock-up were shallow extent axial-radial flaws at 25% and 50% through-weld (Figure 2 of WesDyne Report WDI-TJ-012-03). Because it is common to find single point reflectors in the J-groove weld material associated with welding anomalies, Westinghouse has proceduralized the methodology for determining the difference between a weld anomaly and an indication which is suspected of being a primary water stress corrosion cracking (PWSCC) flaw approaching the triple-point. The two relatively shallow type M flaws in the K mock-up did not provide the linear tip signals, growing towards the triple point, which would be indicative of a potentially leaking flaw. For this reason, these two flaw indications were considered more indicative of typical welding anomaly signals. By contrast, the M type flaw that was successfully detected exhibited a series of tip signals growing in a linear fashion towards the weld triple point. Because of this, the flaw was correctly detected. Entergy believes that the results from this mock-up further demonstrate the ability of this UT technique, and the associated analysis procedures, to consistently detect flaws that have grown to the triple point region. Entergy does not believe that missing the 25% and 50% flaws detracts from the capability of the UT scan to examine the J-groove weld.

The type N and O flaws (circumferential-axial) in the K mockup were designed for evaluation of surface eddy current examinations and were outboard of the stated UT inspection volume of 0.1" into the weld.

c) *Why did Westinghouse have overcalls in the weld during the MRP demo (M, N, and O flaws) and why is that acceptable?*

ANO Response:
During the MRP Phase II demonstrations, Westinghouse made two overcalls during their analysis of the "K" Mock-up, as reported in Table 2 of the MRP Demonstration Report excerpts (Reference 4). There is a Note 5 associated with this portion of the table, which shows that these overcalls are attributed to something that "appears to be welding defects at the tube-to-weld interface". Entergy considers these overcalls to be acceptable because the indications were conservatively called as cracks when they were actually weld-to-tube interface anomalies. This detection resolution that resulted in overcalls is considered a conservative method of detecting flaws at the triple-point region. As discussed in the following paragraph, some false calls are expected in the field due to the difficulties associated with dispositioning indications within the declared inspection volume of the weld.

d) *What effect on conservatism do the overcalls have (i.e. are the technicians calling slag indications cracks, or are they calling crack indications slag?)?*

ANO Response:
During the blind mockup testing, there were two false calls made on the "K" Phase II mockup, which according to Note 5 of Table 2 of the MRP Demonstration Report Excerpts in (Reference 4) appeared to be welding defects at the tube-to-weld interface. This shows the technique to be conservative; because it resulted in calling these weld defects as cracks.

Additionally, field experience with this method has shown that a small number of false calls are regularly made during a reactor head inspection. These must be further investigated by use of surface examination of the J-groove weld. This is considered a normal part of the examination process, and is viewed as a conservative approach to resolving indications that are found with the triple-point inspection technique. The analysis guidelines and training specifically address these points and the approach is to conservatively overcall indications which will initiate further evaluation through use of exploratory surface examinations and/or review of previous inspection data, if available. Several hundred overcalls have been subjected to confirmatory surface exams of the J-groove weld and have consistently confirmed the absence of a weld flaw. Since the ANO-2 inspection is a repeat inspection, the availability of previous data will facilitate this analysis by providing the opportunity for direct comparisons to determine if there is any change in the ultrasonic response.

Overall Summary of the Evaluation of the Triple Point Detection Capability

The "triple-point" is the point at which the root of the J-groove weld, the associated alloy 182 buttering material, and the Alloy 600 penetration tube base material coincide. PWSCC flaws initiating on the surface of the J-groove weld, and propagating in the Alloy 182 material of the weld, would pass through this "triple point" area in order to leak into the annulus of the penetration. When Entergy initially assessed the UT techniques that the industry was employing to interrogate the penetration tubes, it was recognized that these techniques would likely have some inherent ability to see into the J-groove weld for a limited distance. In order to test this theory, Entergy worked with EPRI to construct a penetration tube mockup (now referred to as the "Entergy/MRP mockup"). This mockup contained three (3) stand alone circumferentially-oriented cold-isostatic pressure (CIP) flaws in the weld material, all of which were estimated to extend to within 0.050" of the penetration tube outer diameter (OD). These are flaws 1, 5, and 6. The through-weld depth of these three CIP flaws was 100%, 50%, and 25%, respectively. The 100% through-weld flaw was representative of a circumferential flaw that had extended to the triple-point of the weld and provided a leak path.

The following is an excerpt from information provided by EPRI to Entergy summarizing the results from the blind testing that Westinghouse performed on the Entergy/MRP mock-up. This information provides further confirmation that the UT scan can interrogate into the J-groove weld.

> <u>*Circumferential flaws in the weld & tube*</u>
>
> *... the circumferential-oriented flaws (i.e. flaws in the circumferential-axial plane), in the attachment weld [J-groove weld] were detected during the blind phase of the demo. These are flaws 1, 5 & 6 in the mock-up drawing.*
>
> *The amplitudes of the circ flaws were quite high. Likely because these flaws are oriented more normal to the UT sound beam and the returned signal is a combination of specular and tip-diffracted signals, the specular providing the higher amplitude. Another example of this is the screen image showing the response from the flat-bottomed holes in the mock-up.*

Figure 1 of WesDyne report WDI-TJ-012-03 (Enclosure 2 to Reference 4) provides the sketches that show the flaw dimensions and locations for the Entergy/MRP mock-up. Flaws 1, 5, and 6 are germane to this weld interrogation discussion. Flaw 1, in this mock-up, demonstrated the ability of this technique to detect a circumferential flaw that has penetrated to the triple point of the weld. Flaws 5 and 6 demonstrate the ability of this technique to detect circumferentially oriented flaws in the weld fusion area. In addition to these CIP flaws, there were a series of flat-bottomed holes drilled into the J-groove weld (not shown on this figure). Information informally received from EPRI also refers to these reflectors, as well, which simply states that they further demonstrate the fact that sound is successfully passing in and out of the weld region thus substantiating the capability of this technique.

It should be noted that there were axial-radial CIP flaws also built into the Entergy/MRP mockup. However, these flaws were aligned with corresponding axial tube flaws, which precluded them from being detected by the volumetric UT technique. However, in each case the overlaying nozzle flaw was identified, which would require a surface examination of the weld. Because of these considerations, Entergy does not believe that missing these indications detracts from the case that this technique is effective for detecting flaws in the triple-point region of the weld.

Subsequent to the Entergy/MRP blind mock-up testing, the MRP created an additional set of flawed mock-ups which were blind tested. These were referred to as the "Phase II Demonstrations," which were discussed in detail in the EPRI Demonstration Program Excerpts (Enclosure 3 to Reference 4). There was one mock-up in this most recent set that is referred to as mock-up "K". Mock-up "K" was dedicated exclusively to weld flaws, and was used to test the abilities of both UT and eddy current to interrogate the J-groove weld material for PWSCC type flaws. As shown in the mock-up "K" sketch in the EPRI Demonstration Program Excerpts, there were both axial-radial and circumferential CIP flaws placed in the weld material of this mock-up. The circumferential CIP flaws, however, were very shallow in through-weld extent and located outboard of the stated UT inspection volume of 0.1" into the weld. These flaws were placed in this mock-up for the purpose of demonstrating eddy current surface examination techniques. The CIP flaws of interest to the UT triple-point technique were flaws 2, 7, and 9, according to the generic sketch in the EPRI Demonstration Program Excerpts.

Based on information received from EPRI, each type M flaw was placed 0.0625" away from the OD of the penetration tube. The extent of these flaws was 100%, 50% and 25% through-weld, respectively. In terms of detectability, an axial-radial CIP flaw is the worst case flaw that could be encountered in the weld. The orientation of this flaw, and the fact that it has no facets, makes it the most challenging flaw scenario that would be encountered. WesDyne successfully detected the flaw that was 100% to the triple-point of the weld, which reinforces that this technique is consistently proven to detect flaws that create a leak path in the weld. According to WesDyne, the 25% and 50% through-weld axial-radial flaws in the "K" mock-up were not distinguishable from normal weld interface signals. As discussed previously, Entergy does not believe that missing these flaws in the blind mock-up testing detracts from the capability of this technique for detecting through-weld flaws due to their orientation.

It was also noted on the WesDyne Inspection Results table (Table 2 of Enclosure 3 of Reference 4) that there were two false calls noted on the "K" mock-up. Note 5 which is associated with these overcalls, states that these overcalls were attributed to welding defects at the weld-to-tube interface. The triple-point technique is considered to be a conservative technique for detecting PWSCC at the weld triple-point region. Entergy believes that two welding defects in this mock-up which were analyzed to be cracks, confirms the conservatism inherent in this method. Actual field inspection results from several CE reactor pressure vessel (RPV) heads have consistently demonstrated that the methodology produces conservative overcalls for triple point flaws. Confirmatory surface exams of the J-groove weld have indicated that flaws do not actually exist in the weld in several cases. In future inspections, the ability to compare current inspection results with previous data will reduce the number of false positives since direct comparisons of UT signatures will be possible.

NRC RAI 2:

Pertaining to the Low Frequency Eddy Current examination technique:

a) *What are the weaknesses of LFECT and what are we doing to make up for those in terms of synergies with other examinations (i.e. BMV, supplemental visual, structural integrity analysis, triple point, leak path UT, volumetric UT, and the potential for supplemental surface examinations)?*

   ANO Response:

   The limitation of the low frequency eddy current testing (LF ECT) examination technique is that it has a minimum detection capability of approximately 0.022 in^2 area of metal loss. A bare metal visual (BMV) examination could conceivably detect evidence of a leak created by a lesser area of material loss. However, the LF ECT is not considered to be a stand-alone screening method for potential leakage, but is to be used together with the other available methods to determine the integrity of a given penetration. The "synergy" of Entergy's inspection approaches is discussed in subsection c, and is described fully in the response to RAI 4.

b) *What blind testing is planned to assure that each technician charged with the responsibility of performing analysis of the LFECT data is capable of detecting the minimum flaw size that is expected to be found by this technique?*

   ANO Response:

   A metal loss of 0.022 in^2 can be represented by the 0.015" deep counter-bore change at the top of the Jamesport or new Ginna reactor vessel heads. This occurs over a wide area, and also by a 3/8" wide notch that is 1.5" minimum length and a minimum of 0.060 deep. The response of the eddy current lissajous provides similar results, due to the fact that it is a function of volume and not any other dimension. Therefore, Entergy plans to work closely with Westinghouse Level III personnel to establish a blind test set of data from available mockups that have been gathered using this technique. This data will be used as a blind qualification test for the eddy current analysts that will be supporting the ANO-2 fall outage.

   The available data from the Jamesport and Ginna heads, along with all laboratory mockups, have been compiled. In total, approximately 25 data points are suitable for analyst testing. Since the analysis is straightforward and objective, only five data points will be used for training and the balance for blind qualification of the analysts. Senior Westinghouse personnel will develop an answer key and Entergy will witness the blind testing of the analysts. The Westinghouse personnel administering or developing the test will not be involved in the blind testing. The scope and results of these tests will be provided to the NRC for review.

c) *Explain how LFECT is bounded in terms of detectable flaw size, and why it is acceptable to postulate a leak that this technique can miss (shown through structural analysis)?*

ANO Response:

Through significant laboratory testing performed by Westinghouse, it has been established that this technique is capable of detecting a minimum 0.022 in^2 of carbon steel wastage. This minimum volumetric detection capability was established by testing this technique on a series of mock-ups containing different degradation morphologies, as outlined in WesDyne Report WDI-TJ-001-02 (Enclosure 1 to Reference 4). The minimum volume of metal loss that can be detected was determined from the results of all the differing notch sizes and counter-bore areas that were inspected during the initial testing. Even if a relatively small loss of base metal was not detected by the LF ECT, the other complementary examination techniques would identify a loss of penetration integrity. This would either be by the UT examination of the nozzle, the triple point examination of the J-groove weld, and/or by leakage into the annulus that would be detected by the UT leak path assessment. A leak behind the weld buttering (not experienced by CE heads) would not be detected by the triple point examination, but would be detected by the UT leak path assessment and the LF ECT examination.

An elastic-plastic finite element analysis was performed on the Waterford-3 RPV head that evaluated a condition where RPV head wastage exists over the entire length of either the control element drive mechanism (CEDM) or incore instrument (ICI) penetration annulus with a width equivalent to the width of the J-groove weld. This is equivalent to a 0.75" width radially extended outward from the nozzle which contained a total volume of 127 in^3 for the CEDM enlarged annulus (ICI analysis assumed 190 in^3). The results of the analysis conclude that the remaining attachment weld and vessel cladding can withstand an internal pressure in excess of 7000 psig and not cause a loss of vessel integrity. Therefore, a 0.060" detection acceptance criterion (given a 0.022 in^2 detection area) is well within capability of the LF ECT to ensure any challenges to pressure boundary integrity will be identified well before becoming a safety concern. The assumptions and results from this analysis are comparable for ANO-2.

Overall Summary of the Evaluation of the LF ECT Detection Capability

One of the inspection techniques that is prescribed by the Order is a BMV inspection of the top of the RPV head. The purposes of the BMV inspection are to detect boric acid crystals or residue around the top of the RPV head penetration annulus region and to identify whether wastage at the penetration annulus has occurred. The presence of boric acid can be evidence that PWSCC has created a primary water leak in the alloy material associated with these penetrations. One of the concerns associated with primary water leakage around a penetration is that it will cause the carbon steel base material of the RPV head to corrode. This condition could potentially lead to a significant loss of supporting material around a penetration, and could eventually lead to a failure of the reactor head penetration, if not inspected. With the unique hardship that ANO-2 has for performing a complete BMV examination (discussed in Reference 2) of the reactor head because of the stair-stepped shroud design, Entergy is proposing alternative inspection methods that will provide an acceptable level of quality and safety, consistent with the requirements of the NRC Order. It is recognized that small amounts of leakage through the interference fit region of a penetration annulus is detectable by the zero degree leak path inspection technique, and that this technique has been field demonstrated to detect this condition consistently. However, in order to provide a diverse and complementary method of detecting this possible condition, Westinghouse has developed the LF ECT examination technique. One purpose of this complementary inspection is to also provide a detection capability where there is no interference fit in the annulus and it cannot be determined whether leakage into the annulus has occurred.

The low frequency eddy current technique is designed to measure the degradation of the carbon steel reactor head material in the penetration annulus region. Through laboratory testing performed by Westinghouse, it has been established that this technique is capable of detecting a minimum area of 0.022 in^2 of carbon steel wastage. This minimum volumetric detection capability was established by testing this technique on a series of mock-ups containing different degradation morphologies, as discussed in Enclosure 1 of Reference 4 as well as from the Jamesport and Ginna RPV heads. The minimum volume of metal loss that can be detected was ascertained from the results of the differing notch sizes and counter-bore areas that were inspected during the initial testing. A minimum wastage detection width was determined from measurements on leak paths detected by UT in the North Anna 2 head field inspection. Along with the minimum cross section loss of metal from the LF ECT (0.022 square in), Entergy is establishing the acceptance criteria of a depth of 0.060" detection capability (given a minimum area of 0.022 in^2).

Synergy of Inspection Methods

It is recognized by Entergy that a BMV examination of the top of the reactor head could conceivably detect a leakage path that would represent less than the minimum detectable leak size that is postulated for the LF ECT technique. Because of this, LF ECT is not considered to be a stand-alone detection method for possible leakage, but is to be used together with the other available non-destructive examination (NDE) methods to determine the integrity of a given penetration. The inspection approach to be used for each penetration is to be as depicted and described in Figure 1 in response to RAI 4.

The accessible areas of the RPV head will receive a bare metal visual examination, looking for indications of boric acid residue or wastage that may be present. The accessible areas will include the lower portion of the dome, the flange area, and the annulus region around each of the ICI nozzles. Any residue that is identified will be thoroughly investigated to determine the extent of its contact with the reactor head, as well as any information as to its source. A supplemental visual inspection will also be performed from above the shroud assembly, and inside each of the ICI nozzle doors, again looking for any evidence of boric acid residue. This examination will have the possibility of detecting leakage that has descended onto the RPV head from external sources, as well as having the capability of looking for boric acid residue that may have resulted from penetration leakage to a place where it is visible at the top of the insulation.

Each penetration will be comprehensively NDE inspected. For the RPV head vent line, this will include a wetted surface examination of the J-groove weld and the inner diameter (ID) of the penetration tube for a minimum distance of 2" above the weld. These examinations are expected to detect the initiation of any PWSCC flaws in the alloy material associated with this penetration. The LF ECT examination will supplement the wetted surfaces examination by interrogating the bore of the annulus around this penetration looking for areas of degradation that could be indicative of primary water leakage. For the vent line, the UT leak path detection is not applicable since there is a loose fit and a wetted surface examination is being applied instead. For each CEDM and ICI penetration tube, a full volumetric Time-of-Flight-Diffraction (TOFD) UT examination will be utilized for the purpose of detecting PWSCC indications through the complete volume of the penetration tube, including both the ID and OD surfaces. This UT technique also includes the triple-point inspection capability previously discussed. As part of a separate Order relaxation, the inherent volumetric "blind zones" of some nozzles, not supported by crack growth analysis, will be examined by hand-held eddy current or liquid penetrant inspection techniques.

Also included in the NDE inspection approaches is an examination of the "leak path" interference fit region between the penetration tube and the annulus of the reactor head by the zero degree, straight beam UT technique. This technique has been demonstrated by Westinghouse (Enclosure 4 to Reference 4) to be capable of detecting minute changes in the back reflection response of a penetration tube caused by a leakage path of primary water through the interference fit area. It is expected that any leakage through this interference fit region will be detected by this zero degree, straight beam UT technique. To address the possibility that no interference fit exists, and to provide a complementary and diverse method of detecting carbon steel degradation in this region, the LF ECT will also be used to examine this region.

Overall, the inspection strategy addresses any flaw mechanisms that could cause leakage through the nozzle, through the J-groove weld or behind the weld butter. This combination of approaches addresses each scenario that has been observed to date based on RPV head inspections throughout the industry.

NRC RAI 3:

Pertaining to the Inspection Decision Matrix that ANO-2 is planning to employ during the outage:

a) *How does this LF ECT approach fit into the Decision Matrix, and what inspection frequency considerations have been made in relationship with this technique?*

ANO Response

The decision matrix is designed to determine if any significant flaw exists that initiates on a wetted surface. The base UT examination technique addresses the volume of the nozzle, both the ID and OD nozzle surfaces, and flaws propagating through the J-groove weld to the triple-point. The zero degree, straight beam UT leak detection technique addresses leakage through the interference fit region of the penetrations. The LF ECT technique further augments these inspections by interrogating the RPV head annulus around the penetrations for possible wastage, which also covers the possibility of a lack of interference fit. A positive indication of an OD flaw from any of the ANO-2 examinations will result in a condition identified as "Special Interest." This will require a wetted surface exam on the appropriate flaw location surface. The Westinghouse open housing probe that contains the UT transducers also contains an base eddy current transducer. Therefore, if needed, the base ECT examination of the nozzle ID surface can provide supplemental information on the inner nozzle wall integrity. The nozzle OD surface is primarily inspected by the base UT examination whereby additional examinations will be performed if a flaw is detected. If the suspect surface is the weld, a wetted surface examination of the J-groove weld will be performed. If a surface connected flaw is confirmed from the combination of these inspections, then appropriate action will be taken to repair the penetration and to address the secondary effects (i.e., wastage) associated with through-weld or through-wall conditions.

If a metal loss equivalent to a 0.060" depth by a 0.375 width (0.022 in^2) is detected, the results will be considered as potential wastage and will require further evaluation. However, if the volumetric UT examinations being employed reveal indications of a through-wall or through-weld flaw, any LF ECT results will be further evaluated to determine the extent of the RPV head condition. If the zero degree UT technique indicates that there is no interference fit from what appears to be a leak path, the results of the LF ECT will also be used to further confirm loss of carbon steel. The LF ECT is just one of the multiple NDE methods above that is used to determine penetration integrity.

The future inspection frequency and scope will be determined by the results of the examinations from the fall 2003 refueling outage. This Order relaxation request only addresses the fall 2003 refueling outage inspection scope. Subsequent refueling outage examination and inspection requirements will include NDE lessons learned identified for determining any future NRC requested relaxation. This will also take into consideration any emerging techniques that may improve the present NDE techniques.

b) *Discuss the limitations of the proposed techniques in the Decision Matrix and how the matrix diminishes the weaknesses of these techniques (and how this would be addressed in supplemental examinations or dispositions).*

ANO Response

The decision matrix does not diminish the limitation of the proposed inspection techniques. The individual limitations of the techniques are diminished by the diverse and comprehensive detection processes being applied. The decision matrix provides a roadmap for performance of a confirmatory surface examination or BMV in the event of significant metal loss being identified by LF ECT. All examination techniques have limitations in detecting flaws. The lower limits of detection for the proposed techniques have not been established, but have been shown to provide sufficient sensitivity to detect flaws that can become safety concerns. The table below provides a summary of each technique limitation and how these limitations are mitigated by the complementary examinations proposed by Energy. As depicted, each technique is supplemented by other inspection and examination processes to ensure that challenges to penetration integrity are identified.

Exam Type	Limitation	*Supplemental examinations or dispositions*
Nozzle UT/ECT examination with 7010 inspection probe	Conservatively 10% through wall may not be detectable for certain type of flaws.	If an OD flaw is missed and leakage occurs or propagates into the weld, the triple point exam would detect flaws in the J-groove weld, which have the potential to leak. Additionally, one or more of the following would detect leakage: The zero degree UT leakage assessment, the LF ECT exam, the Supplemental visual, or the BMV of accessible areas of the head. ID flaws would be found with base ID ECT.
Triple Point UT examination	Indication can only be found 0.060 deep into the weld and cracks propagating through the butter and leaking may not be found.	Flaws propagating through the weld and leaking have to go through either the triple point or butter to leak. Flaws going through the J-groove weld will be found through the triple point exam. Evidence of flaws propagating through the butter and leaking will be detected with one or more of the following: the zero degree UT leakage assessment exam, the LF ECT exam, the Supplemental visual, or the BMV of accessible areas of the head.
Zero degree UT Leakage Assessment Exam	The Zero degree transducer cannot assess leakage for those nozzles with limited or no interference fit.	UT of the nozzle and triple point would assure no leakage through the nozzle or J-groove weld. Additionally, the LF ECT exam, the Supplemental visual, and the BMV of accessible areas of the head assure no significant leakage and degradation to the head.
LF ECT exam	LF ECT is limited by a detection area of 0.022 square inches of metal loss; therefore leakage would not be confirmed until slight degradation has occurred in the annulus region of the bore.	The only inspection scenario in which an alternate inspection method is necessary to discern leakage is for those nozzles in which an interference fit is not present and the flaw propagates through the butter and not the triple point or through the nozzle above the J-weld. The LF ECT could detect any significant leakage and minimal head degradation. Additionally, any cracks in the nozzle and triple point will be found with UT, and the Supplemental visual and BMV of the accessible areas of the head will provide other means of detecting potential leakage.

NRC RAI 4:

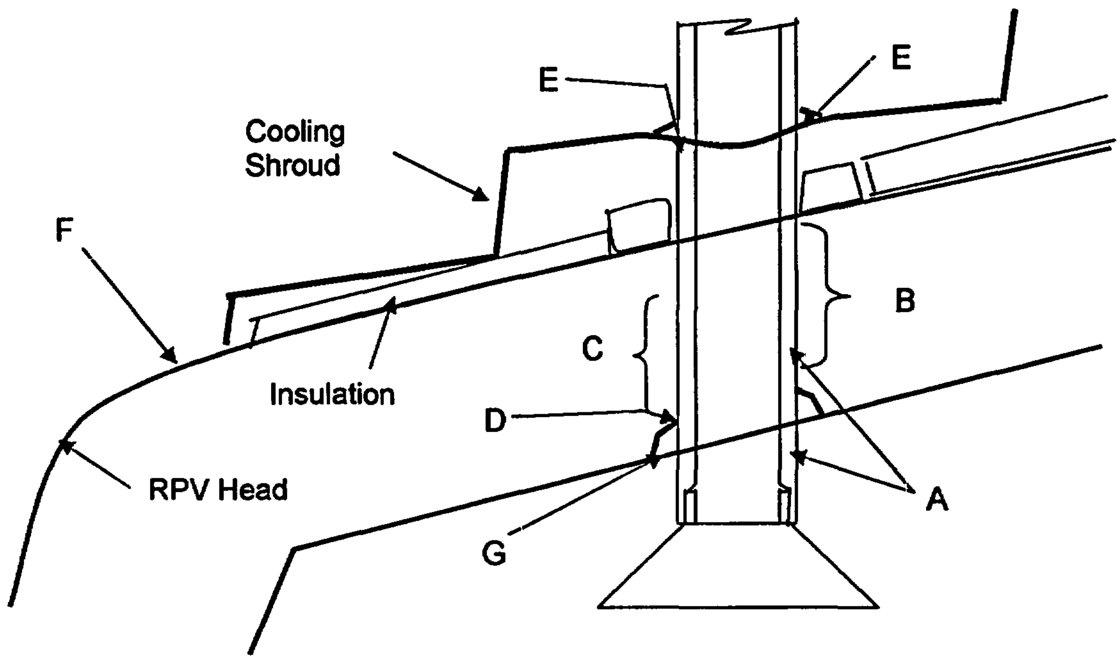
Pertaining to the overall approach address how an acceptable level of quality and safety is met, if the proposed approach represents a reduction from the level that would be provided by BMV (why is this okay?).

ANO Response

The overall approach for ensuring that an acceptable level of quality and safety is being met is provided by the comprehensive examinations of the ANO-2 RPV head in the fall 2003 refueling outage as discussed below. The basis for this conclusion is provided in the subsequent portion of this response by showing compliance to the Order and not having a significant reduction in the level of quality and safety from the proposed inspection regime.

Comprehensive Approach to ANO-2 Reactor Head Inspection - The unique "stair-step" shroud configuration at ANO-2, as discussed in Reference 2, creates a hardship in performing the BMV examination to meet the requirements of NRC Order EA-03-009. Because of this hardship, Entergy has worked closely with Westinghouse to develop new examination approaches, as well as improvements to some of the traditional inspection techniques in order to provide an overall RPV head inspection approach that provides an acceptable level of quality and safety. The ANO-2 reactor head inspection approach that is being applied in lieu of a BMV inspection for the fall 2003 refueling outage is a comprehensive methodology. This inspection regimen is designed to provide defense in depth for detection capability of any PWSCC flaw that could develop in the J-groove weld or penetration nozzle. This comprehensive approach combines the use of several diverse and complementary inspection techniques. These techniques culminate to provide a complete examination and inspection of the RPV head which provides an appropriate level of quality and safety. This complementary inspection approach is best illustrated by the following sketch (Figure 1) which demonstrates how each examination and inspection technique covers the entire length of the penetration to ensure that PWSCC indications are found in the nozzle or J-groove weld, penetration leakage is detected, and that the RPV head integrity is maintained.

Figure 1



Primary Examinations

A = **Volumetric Examination** of CEDM/ICI penetration tubes utilizing MRP demonstrated UT techniques. This ensures that the critical length of the nozzle is free of defects and potential leakage paths.

B = **Low Frequency Eddy Current Examination** of the portion of the CEDM and vent line penetrations that are above the J-groove weld. This examination will interrogate the area between the penetration tube and the reactor head looking for degradation of the carbon steel head material.

C = **Penetration Annulus Leakage Assessment** using Westinghouse demonstrated zero degree UT technique. This ensures that the leak path from a leaking nozzle or weld will be detected and qualitatively determined to have a loss of interference fit through the annulus which can also be detected by LF ECT. This examination can detect leakage through the J-groove weld or through the buttering, if it were to occur.

D = **Triple-Point Examination** utilizing Entergy/Westinghouse developed and EPRI/MRP demonstrated UT technique. This process provides the unique capability to further investigate 0.060" into the J-groove weld and determine the integrity of the penetration weld and to support the conclusion that boric acid deposits will not be present on the RPV head.

E = **Supplemental Visual Inspection** performed from above the cooling shroud plate, which has the capability of detecting boric acid that has either descended onto the head from above, or has migrated upward from the head and may be visible at the top of the reactor head insulation.

F = **Bare Metal Visual Inspection** of the accessible portions of the RPV head, including the flange area, part of the lower dome, and around the annulus of the ICI nozzles. This examination is performed to detect corrosion that may have occurred in the accessible areas, to detect leakage around the ICI nozzles, and to look for evidence of boric acid residue that may have run down the head from a leaking penetration.

Conditional Examination

G = **Surface Examination of J-Groove Weld** utilizing liquid penetrant or eddy current. This is a contingency examination that would be utilized to further investigate a positive indication of a potential PWSCC flaw found with any of the primary examination techniques.

Compliance with Section IV. F of NRC Order EA-03-009 for Ensuring an Acceptable Level of Quality and Safety - Section IV.C (1) (a) of the Order requires a bare metal visual examination of 100% of the RPV head surface (including 360° around each RPV head penetration nozzle). Since ANO-2 is unable to effectively remove the cooling shroud and insulation package due to its design, Entergy is seeking relaxation from the Order. The basis for the hardship in not being able to effectively perform a BMV inspection is contained in the original Order relaxation request (Reference 2). Section IV.F of the Order provides two alternatives for seeking relaxation. Specifically, a request for relaxation regarding inspection of specific nozzles shall address the following criteria:

(1) The proposed alternative(s) for inspection of specific nozzles will provide an acceptable level of quality and safety, or

(2) Compliance with this Order for specific nozzles would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety.

The purposes of the BMV inspection are to detect boric acid crystals or residue around the top of the RPV head penetration annulus region <u>and</u> to identify whether wastage at the penetration annulus has occurred. No other examination process can provide this specific capability since it requires a direct visual or boroscopic inspection of the entire surface of the head. However, in light of the examination techniques being proposed for the ANO-2 fall 2003 refueling outage, Entergy believes that the overall level of quality and safety will not be significantly reduced by not performing a bare metal visual examination. This is based on the following discussion.

The current ANO-2 RPV head design contains Alloy 600 penetrations that are susceptible to PWSCC cracking. Boric acid deposits that may be identified around the annulus of an RPV head penetration would likely be indicative of a leak through the nozzle or through the accompanying J-groove weld or weld butter due to PWSCC. Any leakage through the CEDM, ICI, or vent line penetrations needs to be detected in a timely manner to ensure that a pressure boundary leak is addressed. For ANO-2, the primary means of determining whether a penetration has experienced a PWSCC flaw will be by performing a UT and leak path assessment in accordance with Section IV.C(1)(b)(i) of the Order. A leaking nozzle will reveal itself by the primary method of examination, but will also likely reveal itself visually from boric acid deposits around the top of the annulus. Boric acid deposits in and of themselves are not a safety concern based solely by their presence on the head. Boric acid deposits are only a concern when a leaking penetration has provided a wetted condition over several cycles of operation. Entergy performed a complete UT examination of all CEDM and ICI nozzles in the previous refueling outage and determined that the ANO-2 RPV head penetrations have not experienced PWSCC thus ensuring that there have not been previous penetration leaks which would contribute to conditions for wastage. Entergy will be performing a BMV inspection of the eight ICI nozzles which is in compliance with IV.C(1)(a) of the Order. Entergy will also be performing a BMV inspection of the RPV head flange and the exposed portion of the RPV head up to the cooling shroud as well as an inspection of the top of the cooling shroud above each of the CEDM penetrations and the vent line. As part of the bare metal visual examinations of the ICI penetrations, Entergy will also inspect many of the neighboring CEDM penetrations for the presence, or absence, of boric acid. Any significant leakage is expected to be visible due to flow of boric acid from upper penetrations. Therefore, any boric acid deposits that are present in the inspected areas will be detected and any significant boric acid deposits due to leaking CEDM penetrations will be detected.

In addition to the requirements of the Order, the Entergy proposed triple point UT examination process examines up to 0.060" into the J-groove weld. This provides the additional ability to evaluate whether a through-weld flaw in the J-groove weld has occurred. This examination technique serves to provide additional confidence in compliance to Section IV.C(1)(b)(i) of the Order for penetration integrity. Maintaining the overall integrity of any penetration also ensures that there is no active boric acid in, or above, the penetration annulus. Although it cannot be positively concluded that there will be no boric acid deposits on the ANO-2 head around the CEDMs and vent line, there will be a high confidence that there are no leaking penetrations that would have provided a pathway for any boric acid deposition.

The UT leak path assessment aids in providing knowledge that the integrity of the pressure boundary is intact. This technique supplements the UT examination of the penetration nozzle as required by the Order. However, it also serves to provide additional information for both the UT triple point and LF ECT examinations proposed by Entergy. If a through-weld flaw is detected by the triple point exam, it will confirm the telltale signs of leakage through the riverbed indication. The leak path assessment will also provide an initial indication of leakage that will be indicative of loss of metal at or near the nozzle annulus from the LF ECT exam. If a through-butter flaw exists, even though not expected, the leak path UT exam will confirm leakage. In the event that an interference fit does not exist, the UT leak path examination will not detect leakage. In this case the LF ECT examination will provide additional detection capability.

Entergy's new LF ECT technique will provide a commensurate level of quality and safety to that of a BMV inspection. The primary process for determining whether wastage has occurred or could be occurring is through the use of the LF ECT technique. This technique has the ability to detect a loss of carbon steel over a 0.022 in^2 area. The acceptance criterion that will be used at ANO-2 for evaluating the potential for wastage will be a metal loss equivalent to a 0.060" depth or greater. This process not only determines whether wastage has occurred at the top of the RPV head, but can also determine wastage below the surface of the head in the annulus. As a result, Entergy believes that the use of the LF ECT technique, in conjunction with the other NDE methods being employed, exceeds the

Order expectations for wastage evaluation. As discussed in the response to RAI 2 (c) above, the detection capability of the LF ECT techniques is significantly more sensitive for detecting wastage than would present a safety concern for the RPV head metal loss around a penetration. Therefore, the LF ECT technique has the capability to detect wastage long before it would become a safety concern.

Therefore, Entergy believes the additional examination techniques of the LF ECT and the UT triple point examinations, in combination with the existing NDE method, being performed during the ANO-2 fall 2003 refueling outage provide a comprehensive inspection program in lieu of a 100% BMV inspection and do not significantly reduce overall level of quality and safety required by the Order.

List of Regulatory Commitments

The following table identifies those actions committed to by Entergy in this document. Any other statements in this submittal are provided for information purposes and are not considered to be regulatory commitments.

COMMITMENT	TYPE (Check one)		SCHEDULED COMPLETION DATE
	ONE-TIME ACTION	CONT. COMP	
Entergy will provide the results of the LF ECT blind testing to the NRC.	X		60 days after the ANO-2 fall 2003 outage